TMDL Compliance Model Instructions & Assumptions, Version 6
Bunker Hill Mine Water Management
Developed by Matt Germon/CH2M HILL for EPA Region 10

Introduction

This model was developed to assist EPA Region 10 in evaluating the treatment and storage of acid mine drainage coming from the Kellogg Tunnel (KT) at the Bunker Hill Mine in Idaho. The model allows input of Central Treatment Plant (CTP) size and CTP effluent concentrations and calculates the volume of AMD storage, and in some cases the volume of treated water storage, required to meet EPA Water Group's Draft Total Maximum Daily Loads (TMDLs) for the Coeur d'Alene Basin for five water years (1973, 1982, 1981, 1987, and 1996). These five water years were selected to represent a range of KT flow conditions based on available KT data. More information on the relationship between KT and SFCdA, and the development of synthetic SFCdA flows at Pinehurst, is presented in the draft *Hydrologic Evaluation of the Kellogg Tunnel and South Fork Coeur d'Alene River*, CH2M HILL, July 1999.

Instructions

When first opening the spreadsheet, Excel will ask if **links to other worksheets** should be updated. Click no. A **circular reference** will then be identified. Click cancel. Circular references are necessary to build the charts. They can be used in Excel, but the number of iterations under Tools/Options/Calculations should be set to 5 or less.

Input parameters required to operate the model are summarized in the "Input" worksheet. They include CTP size, treated storage size, and CTP effluent concentrations for cadmium, lead, and zinc. If a mitigation is being evaluated, the percent reduction in KT flow needs to be entered. Also, the TMDL calculation method (interpolated or step) needs to be specified, and the percent allowable load should be entered (in most cases this is 100 percent). An alternative use of treated water (e.g., irrigation) is provided as an option. If selected, the actual water use hydrograph needs to be input into the 'Alt. Water Use' worksheet. The existing hydrograph assumes irrigation of 100 acres of hillsides; the acreage may be increased in the input as well. The TMDLs are based on EPA's draft TMDLs for the Coeur d'Alene Basin, changes may be necessary when the final TMDLs are available.

After all input parameters are entered into the model, the model output is presented in the 'output' section of the "Input" worksheet. The output is also placed into data tables and can be viewed graphically in the graph worksheets. The data tables require updating (due to presence of circular references) after any input parameters is changed (except CTP size). To update, enter in each CTP size included in the data tables. This will update all storage-related output used to plot the summary graphs "Storage" and "Storage + Mitigations".

Model Logic and Assumptions

Model logic and assumptions are presented by category below.

TMDL Calculation -

Interpolated TMDLs are calculated for a given SFCdA flow condition from the nearest corresponding flow conditions. For example, the cadmium waste load allocation for SFCdA flow of 150 cfs would be calculated by interpolating between the load allocation for the 10% flow condition (97 cfs, 0.00506 lb/day) and the 50% flow condition (268 cfs, 0.01920 lb/day). The result would be 0.00944 lb/day. Waste load allocations are not interpolated beyond the 90% flow condition. This interpolation method is currently being considered by the EPA Region 10 Water Group.

Step TMDLs are determined as follows: for SFCdA flows between zero and 10%, the 7Q10 flow condition applies. For SFCdA flows between 10% and 50%, the 10% flow condition applies. For SFCdA flows between 50% and 90%, the 50% flow condition applies. Finally, for SFCdA flows greater than 90%, the 90% flow condition applies. For example, the cadmium waste load allocation for SFCdA flow of 150 cfs would be 0.00506 lb/day.

The percent allowable load feature was built into the model to evaluate the effect of slight increases in the allowable load to the SFCdA. The percent allowable load is multiplied by the interpolated or step TMDL to calculate the allowable load to the SFCdA on a daily basis. This feature can be effectively turned off by setting the percent allowable load to 100.

The model forces CTP discharge to meet allowable loads by calculating an allowable discharge (in gpm) on a daily basis. The allowable discharge is calculated by dividing the TMDL by the CTP effluent concentration, and selecting the lowest value for the three metals. For a 100 percent allowable load, the annual TMDL compliance will always be less than 100 percent because some days the capacity of the CTP will not be able to match the allowable load of SFCdA.

Hydraulic Routing -

The model attempts to match KT flow with CTP size on a daily basis. If KT flow exceeds CTP size, the excess is diverted to Storage (termed 'hydraulic storage'). If KT flow is less than CTP size, Storage is pumped to match CTP size (as long as storage is not 'empty').

Daily KT flow measurements were interpolated for those days when data were missing. Average KT flow for each year was calculated using actual and interpolated KT flow data.

Storage starts at zero and cannot be less than zero during a water year.

Actual alternative water use (gpm) is determined by the alternative water use demand (e.g., amount of water required to irrigate 100 acres or more for different months). This number cannot be higher than the CTP capacity or the KT flow, unless treated water in storage is used as alternative water in addition to the treated water from the CTP.

Effective CTP discharge (gpm) is calculated on a daily basis by subtracting INTO Storage and subtracting Alternative Water Use and adding OUT OF Storage to KT flow. This number cannot be higher than the CTP size.

The model assumes that exact pump rates can be achieved when pumping from or diverting to Storage or Treated Storage. For instance, if KT flow is 3510 gpm and CTP capacity is 3500 gpm, exactly 10 gpm can be diverted to Storage.

Loading Analysis -

If the hydraulic load from the effective CTP discharge is greater than the allowable discharge (a flow rate based on loading for the limiting metal), then the excess flow is diverted. The model will first divert treated water to Treated Storage until it is full, unless it is zero. The model will then divert untreated water to Storage (termed 'TMDL storage').

If the effective CTP discharge is less than the allowable discharge (metal load-based), the model will pump from Treated Storage until it is empty. The pump rate from Treated Storage to the SFCdA is not limited. Note that for some days the effective CTP discharge cannot be increased to match allowable discharge because it is either at CTP capacity, or it is less and Storage is empty.

Cumulative Storage is the combined hydraulic and TMDL (metal load-based) storage diverted into Storage after subtracting volumes pumped out of Storage, calculated on a daily basis.

Total CTP Discharge is the actual rate of discharge from the CTP considering all diversion to and from Storage, Treated Storage, and Alternative Water Use for a given day.

Actual mass loading is calculated for each metal by using the corresponding CTP effluent concentrations and Total CTP Discharge. The results are expressed as percent of allowable discharge for each metal over the entire water year.

Alternative Water Use -

The Treated Storage pond is used as a reservoir for the alternative use of water. Even if treated storage is set to zero, if alternative water use option is selected in the input sheet, alternative water use will be incorporated in the results of the model. In the event that treated water can be pumped for discharge to SFCdA and treated water can also be used for alternative use, alternative water use takes precedence over discharge to SFCdA. In the event that alternative water use demand is higher than the amount of water treated at the CTP, any treated water stored in the treated storage pond will be used to meet the alternative water demand.

Mitigation Effectiveness -

The model was built to provide insight into the effectiveness of various AMD mitigations. This is conducted by calculating an adjusted KT flow that represents a reduction due to mitigation measures. The calculation is based on a percent reduction. For instance, a 10% KT flow reduction would result in a daily KT hydrograph with values that are 90% of the actual values for a given water year. Version 4_Dale of the Model allows input of variable % KT flow reductions for different ranges of KT flow (e.g., 60% reduction for KT>3500 gpm, 50% reduction for 3500>KT>2500, 40% reduction for 2500>KT>1500, 30% reduction for 1500>KT). The hydraulic results of the reduction can be viewed in the difference between maximum and average KT flows with and without the reduction. The rest of the analysis is similar to the analysis without mitigations as described above.

Example Input

TMDL Compliance Model Input/Output, Version 6_max
Bunker Hill Mine Water Management
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Input:

CTP/Treated Storage Size:		**Mitigation Effectiveness:**	% KT Flow Reduction
CTP size (gpm)	6,000	KT>3500 gpm:	60
Treated Storage size (Mgal)	0.0	3500 gpm>KT>2500 gpm:	50
Effluent Concentrations:		2500 gpm>KT>1500 gpm:	40
Cadmium (ug/L)	0.50	1500 gpm>KT:	30
Lead (ug/L)	3.0	**TMDL Selection:**	
Zinc (ug/L)	50.0	Interpolated or Step ("I" or "S")	S
Alternative Water Use:		Percent Allowable Discharge	100
Include Alt. Use? ("Y" or "N")	N	**Acreage Irrigated:**	
		(1=100, 2=200, 3=300)	1

Draft TMDLs:

Flow Condition	Flow (cfs)	Cd (lb/day)	Pb (lb/day)	Zn (lb/day)
7Q10	68	0.02340	0.13400	2.42000
10%	97	0.03100	0.17600	3.20000
50%	268	0.06620	0.33300	6.56000
90%	1290	0.10500	0.29500	8.84000

Output:

Water Year	1973	1974	1981	1982	1996
Maximum KT Flow (gpm)	6,700	6,000	4,062	4,114	4,025
Average KT Flow (gpm)	2,338	1,877	1,831	2,209	1,421
Storage Required					
Maximum (Mgal)	5.4	0.0	0.0	0.0	0.0
Remaining at End of Water Year (Mgal)	0.0	0.0	0.0	0.0	0.0
eated Storage Remaining at End of Water Year (Mgal)	0.0	0.0	0.0	0.0	0.0
% Hydraulic Storage	25%	0%	0%	0%	0%
% TMDL Storage	75%	0%	0%	0%	0%
Alternative Water Demand (Mgal)	68.2	68.2	68.2	68.2	[illegible]
Actual Alternative Water Used (Mgal)	0.0	0.0	0.0	0.0	0.0
Volume of Water Pumped from Storage (Mgal)	8.2	0.0	0.0	0.0	0.0
Volume of Water Diverted to Storage (Mgal)	8.2	0.0	0.0	0.0	0.0
Volume of CTP Discharge (Mgal)	[illegible]	929.8	880.4	[illegible]	713.8
Annual TMDL Compliance					
% Allowable Cadmium Load	24%	15%	16%	20%	11%
% Allowable Lead Load	31%	23%	23%	29%	18%
% Allowable Zinc Load	24%	16%	17%	22%	13%
Storage Required w/ Mitigation					
Maximum KT Flow (gpm)	3,430	3,150	2,375	2,396	2,360
Average KT Flow (gpm)	1,491	1,259	1,235	1,462	949
Maximum KT Flow Reduction (gpm)	3,270	2,850	1,687	1,718	1,665
Average KT Flow Reduction (gpm)	847	618	596	747	472
Maximum (Mgal)	0.0	0.0	0.0	0.0	0.0
Remaining at end of water year (Mgal)	0.0	0.0	0.0	0.0	0.0
eated Storage Remaining at End of Water Year (Mgal)	0.0	0.0	0.0	0.0	0.0
% Hydraulic Storage	0%	0%	0%	0%	0%
% TMDL Storage	0.0%	0%	0%	0%	0%
Actual Alternative Water Used (Mgal)	0.0	0.0	0.0	0.0	0.0
Volume of Water Pumped from Storage (Mgal)	0.0	0.0	0.0	0.0	0.0
Volume of Water Diverted to Storage (Mgal)	0.0	0.0	0.0	0.0	0.0
Volume of CTP Discharge (Mgal)	716.8	618.3	599.4	705.4	475.5

Chart Output:

Storage (Mgal) vs. CTP Size (gpm)

	1973 - Ma›	1974 - Ma›	1981 - Ma›	1982 - Ma›	1996 - Maximum
1500	409.6	207.2	193.0	372.4	161.4
2000	235.5	63.5	76.6	165.6	88.9
2500	154.3	43.8	9.1	50.9	41.9
3000	85.5	33.7	4.2	8.4	13.8
3500	52.9	24.0	0.8	3.5	2.5
4000	30.8	15.7	0.1	0.5	0.0
5000	7.9	4.6	0.0	0.0	0.0
6000	5.4	0.0	0.0	0.0	0.0

Storage Remaining (Mgal) vs. CTP Size (gpm)

	1973 - Ren	1974 - Ren	1981 - Ren	1982 - Ren	1996 - Remaining
1500	402.9	207.2	193.0	372.4	77.7
2000	162.5	27.6	76.6	163.5	0.0
2500	0.0	0.0	1.7	23.7	0.0
3000	0.0	0.0	0.1	0.0	0.0
3500	0.0	0.0	0.0	0.0	0.0
4000	0.0	0.0	0.0	0.0	0.0
5000	0.0	0.0	0.0	0.0	0.0
6000	0.0	0.0	0.0	0.0	0.0

Treated Storage Remaining (Mgal) vs. CTP Size (gpm)

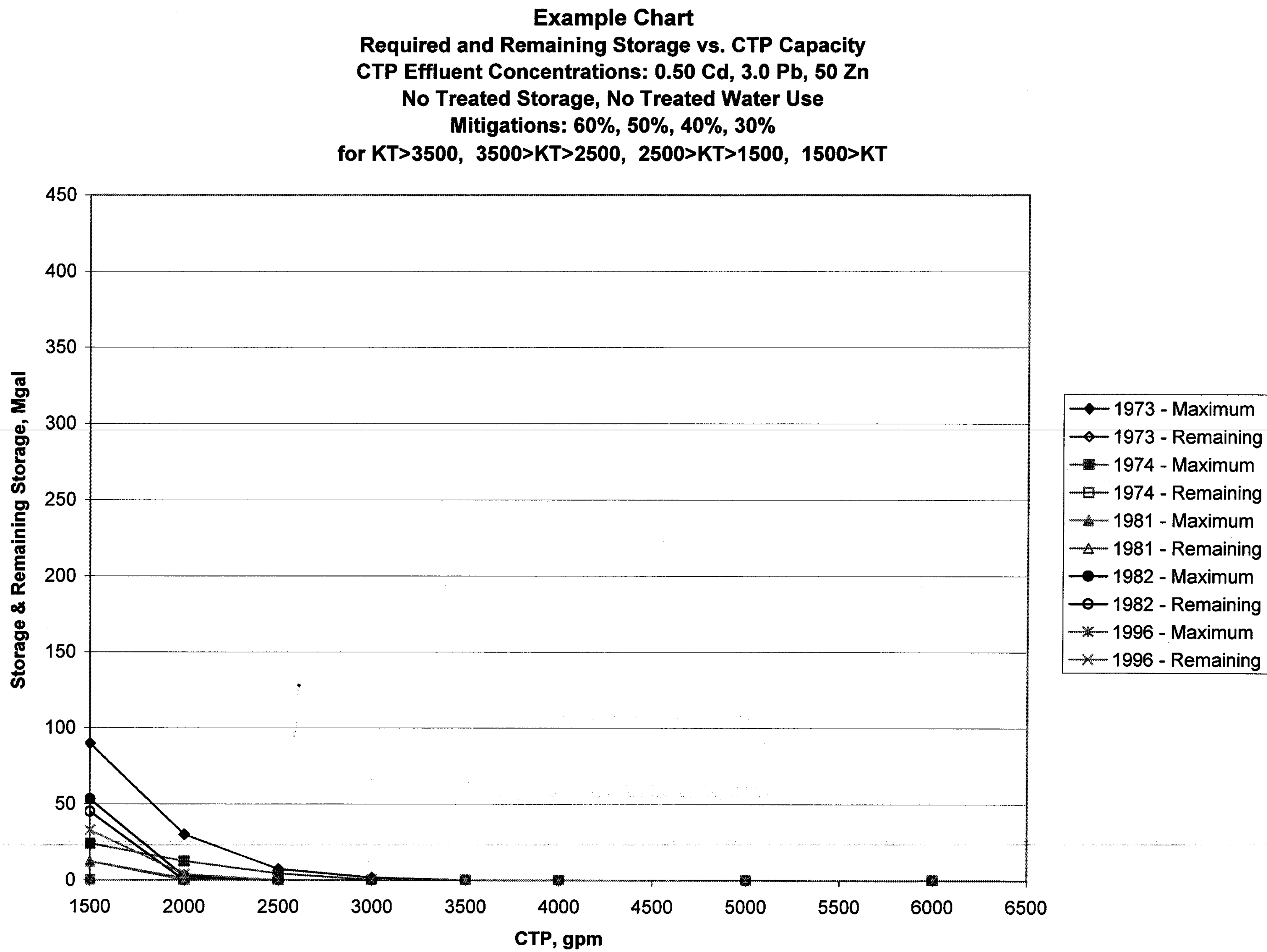
	1973	1974	1981	1982	1996
1500	0.0	0.0	0.0	0.0	0.0
2000	0.0	0.0	0.0	0.0	0.0
2500	0.0	0.0	0.0	0.0	0.0
3000	0.0	0.0	0.0	0.0	0.0
3500	0.0	0.0	0.0	0.0	0.0
4000	0.0	0.0	0.0	0.0	0.0
5000	0.0	0.0	0.0	0.0	0.0
6000	0.0	0.0	0.0	0.0	0.0

Storage (Mgal) w/Mitigation vs. CTP Size (gpm)

	1973	1974	1981	1982	1996
1500	89.8	24.1	12.3	53.2	32.8
2000	30.0	12.4	1.2	2.6	3.8
2500	7.3	4.3	0.0	0.0	0.0
3000	1.7	0.2	0.0	0.0	0.0
3500	0.0	0.0	0.0	0.0	0.0
4000	0.0	0.0	0.0	0.0	0.0
5000	0.0	0.0	0.0	0.0	0.0
6000	0.0	0.0	0.0	0.0	0.0

Storage Remaining (Mgal) w/ Mitigation vs. CTP Size (gpm)

	1973	1974	1981	1982	1996
1500	0.0	0.0	12.3	45.0	0.0
2000	0.0	0.0	0.0	0.0	0.0
2500	0.0	0.0	0.0	0.0	0.0
3000	0.0	0.0	0.0	0.0	0.0
3500	0.0	0.0	0.0	0.0	0.0
4000	0.0	0.0	0.0	0.0	0.0
5000	0.0	0.0	0.0	0.0	0.0
6000	0.0	0.0	0.0	0.0	0.0



TMDL Compliance Model Version 6_max.xls

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